Ministry
of
Transportation
Ontario

FREIGHT DISTRIBUTION SERIES
VOLUME 2

POTENTIAL SAVINGS THROUGH THE ELIMINATION OF EMPTY TRUCK MOVEMENTS
(The Cost of Regulation)

Goods Distribution Systems Office
Provincial Transportation Division

March 1989

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FORWARD

In 1987, the Ministry of Transportation, Ontario undertook a truck transportation survey in order to provide input for the development of a truck costing model, and to gather specific information for several areas in the ministry.

The survey data was used to examine the occurrence of empty truck movements between northern and southern Ontario, the results of which were published in a 1988 Canadian Transportation Research Forum (CTRF) report entitled "The Costs and Potential Savings of Empty Truck Movements Occurring Between Northern and Southern Ontario", by William Raney, Goods Distribution Systems Office, Ministry of Transportation, Ontario. The initial analysis of empty movements concentrated on the Toronto to Northern Ontario leg of intraprovincial movements on Highway 400.

The survey revealed that 36% of the southbound moves and 24% of the northbound moves involved empty vehicles. With better matching of loads between Northern and Southern Ontario, it was determined that 54% of the empty movements or 10% of the empty kilometres driven could be eliminated, representing a savings of $12 million annually in the cost of truck transportation. The majority of the identified reductions were found to be possible only with:

1. Substantial change in market entry constraints, and
2. The establishment of an information system which would enable the effective matching of loads.

Because the initial analysis dealt only with the Toronto leg of traffic flows between Northern and Southern Ontario, it was recommended that a detailed analysis be performed on empty truck movements in the major transportation corridors of the province.

The following paper presents the results of analysis of empty movements on corridors leading from Toronto. Data obtained from inspection stations on Highway 401, the Queen Elizabeth Way, and Highway 400 are analysed to determine the applicability of the earlier findings to other parts of Southern Ontario.

The survey interview data disclosed that a significant proportion of trucks in all three corridors were travelling empty, and that the proportion of trucks which were empty was highest during "rush hour" periods. This suggests that a reduction in the number of empty truck movements through load matching would likely result in a reduction in total traffic volumes during peak use hours.

Using the load matching methodology developed in the initial study, empty movements were matched for each of the three corridors. It was found that over 50% of empty trips could be eliminated annually in each of the three corridors, reducing the number of kilometers driven empty by at least 40%. This would amount to a 9.5% to 18.3% reduction in truck traffic volumes at the survey points, and a 6.0% to 7.2% reduction in total kilometers driven annually.

The costs incurred for empty movements would similarly be reduced by 36.7% to 57.2%; this translates into an annual savings of $26.7 million in the Highway 400 corridor, $31.6 million in the Q.E.W. corridor, and $40.9 million in the Highway 401 corridor.

As was found in the earlier study, the majority of these potential savings are possible only through changes in market entry constraints; less than one-quarter of the savings would be possible under the market restrictions in place at the time of the survey. Because of the high level of extraprovincial truck traffic on the Q.E.W. and Highway 401, a load matching information system would have to be interprovincial and/or international in scope in order to fully realize potential savings in these corridors.

An abridged version of the report is published as part of the 1989 CTRF proceedings, under the title "Potential Savings Through the Elimination of Empty Truck Movements (Abridged)", W. Raney and K. Siwak, Goods Distribution Systems Office, Ministry of Transportation, Ontario.

For more information on this and other papers in the **Freight Distribution Series**, please contact Bill Raney, Senior Costing Advisor, or Karen Siwak, Logistics Analyst, at:

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A. INTRODUCTION

During the summer of 1987, over 10,000 interviews were conducted with truck drivers at inspection stations throughout Ontario (see Appendix A for survey methodology). Initial analysis of survey data on a single corridor revealed that a substantial percentage of trucks were travelling empty, and that significant savings in transportation costs and trucking kilometers driven were attainable through improved matching of loads.[1] Such reductions in empty movements have implications for reducing transportation costs for shippers, and for addressing some of the traffic congestion problems on Ontario's highways.

In order to determine the applicability of earlier findings to other areas of Southern Ontario, data from inspection stations on Highway 401, the Queen Elizabeth Way, and Highway 400 were isolated and analysed in terms of volume of traffic, route distribution, occurrence and cost of empty movements, and potential savings through improved load matching.[2] This paper will discuss the results of this analysis.

B. CORRIDOR PROFILES

The original intention of this study was to analyse data for each of the four corridors leading out of Toronto. Unfortunately, survey data obtained for the Highway 401 corridor from Toronto to Windsor was found to be unusable. Thus, the analysis was performed on the three corridors leading north, east and south from Toronto.

i. Location

The distribution of survey points in Southern Ontario is illustrated in Map I (p. 2), with each survey point consisting of a pair of inspection stations (one in each direction) at which the interviews were held.

Maps II to IV illustrate the area surrounding each of the survey points. The northbound station for **Highway 400** is located approximately 24 kilometers north of the Highway 400 - Highway 401 junction, while the southbound station is located approximately 15 kilometers north of junction (Map II, p. 2). The distance between these stations affected the survey results for the Highway 400 corridor, where local traffic between Toronto and parts of York Region could only be captured at the southbound station.

The **Highway 401** inspection stations are located near the town of Gananoque (Map III, p. 3). The eastbound station is located east of the junction for the U.S. Interstate 81, so that north/eastbound traffic between Eastern Canada and the U.S. was captured, while corresponding south/westbound traffic was not.

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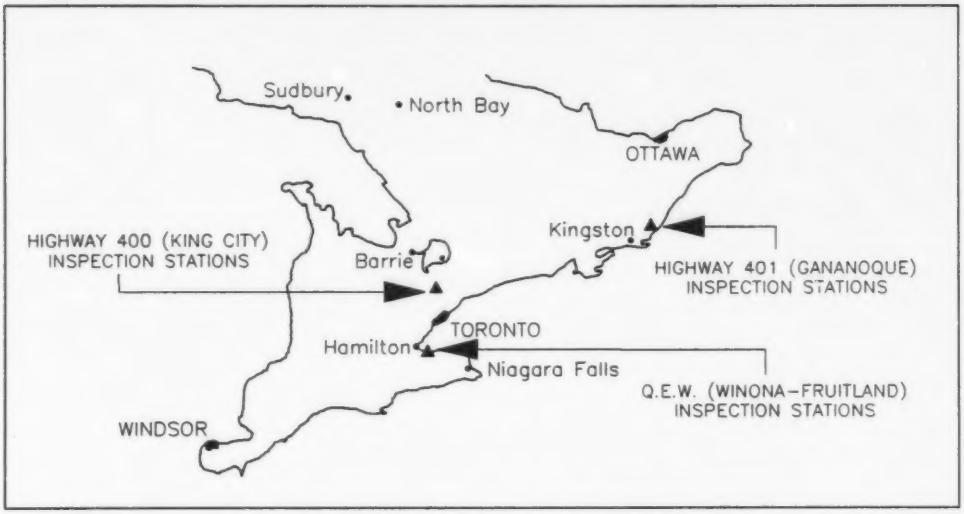
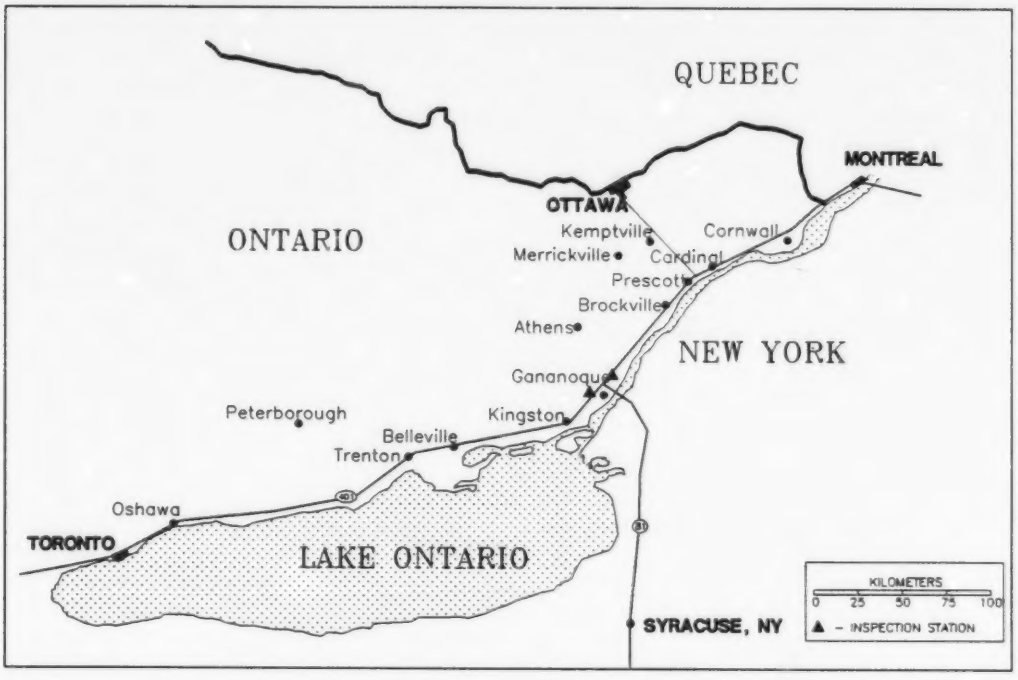
1. See Costs and Potential Savings of Empty Truck Movements Occurring Between Northern and Southern Ontario, William Raney, Goods Distribution Systems Office, Ministry of Transportation, 1988.
2. Load matching, which is described in detail on p. 12, consists of identifying potential backhaul loads for empty trucks.

MAP I: Location of Inspection Stations

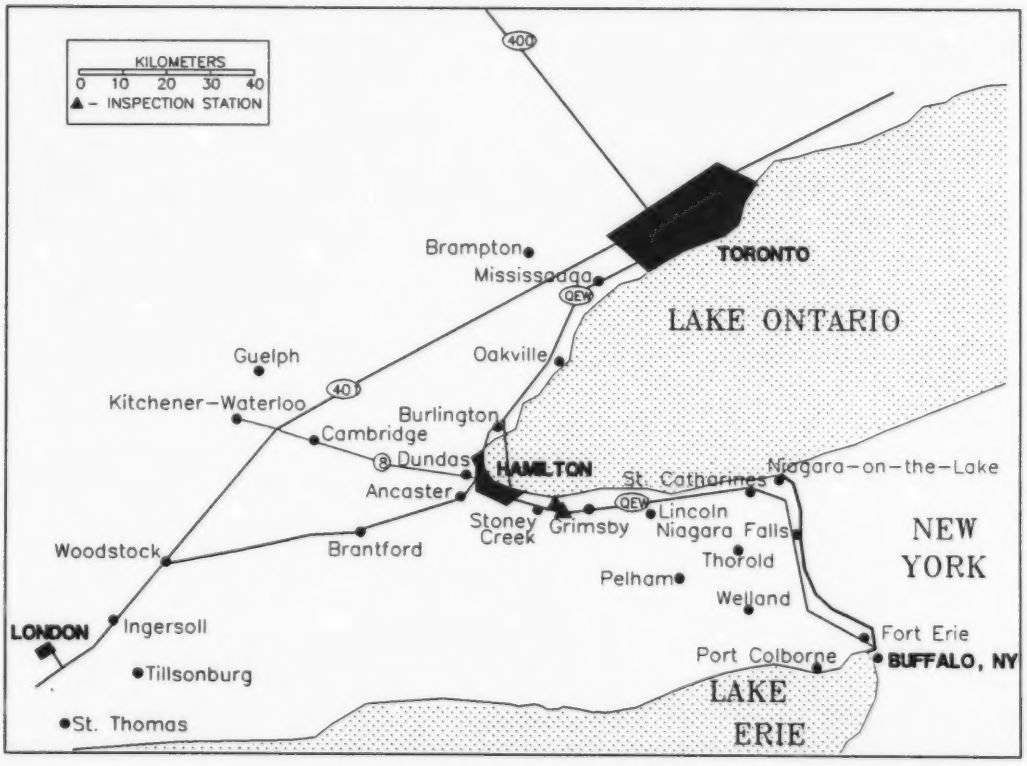


MAP II: Highway 400 Corridor

MAP III: Highway 401 Corridor



MAP IV: Queen Elizabeth Way Corridor



The **Queen Elizabeth Way** (Q.E.W.) stations are located southeast of the town of Stoney Creek (Map IV, p. 3). The small distance between the northbound station and the southbound station does not appear to have affected the survey results obtained for the Queen Elizabeth Way corridor.

ii. Demographics in Inspection Station Areas

The number, size and population of cities and towns surrounding the survey points play a significant role in the type and volume of traffic which passes the stations, which in turn affected the survey results. Generally, the volume of local traffic in southern Ontario increases in direct proportion to the population density in the area. Some general demographic statistics for the counties around the three survey points are provided in Table I.

TABLE I: INSPECTION STATION AREA DEMOGRAPHIC STATISTICS

	HIGHWAY 401 CORRIDOR		HIGHWAY 400 CORRIDOR		QUEEN ELIZABETH WAY CORRIDOR	
COUNTIES NEAREST TO INSPECTION STATIONS	UNITED COUNTIES OF LEEDS & GRENVILLE	COUNTY OF FRONTENAC	MUNICIPALITY OF METROPOLITAN TORONTO	REGIONAL MUNICIPALITY OF YORK	REGIONAL MUNICIPALITY OF HAMILTON - WENTWORTH	REGIONAL MUNICIPALITY OF NIAGARA
1985 POPULATION	83,176	117,878	2,154,437	324,064	421,136	369,312
PEOPLE PER HECTARE	0.2	0.3	33.8	1.9	3.8	2.1
% OF PEOPLE RESIDING IN RURAL AREAS	56.6%	48.8%	3%	18%	2.2%	4.3%
INCORPORATED CITIES, TOWNS, TOWNSHIPS, AND BOROUGHS (1985 POPULATION)	BROCKVILLE (20,760) GANANOQUE (4,844) PRESCOTT (4,585) KEMPTVILLE (2,496) CARDINAL (1,651) MERRICKVILLE (994) ATHENS (934)	KINGSTON (117,878)	TORONTO (606,247) NORTH YORK (555,308) SCARBOROUGH (461,997) ETOBICOKE (298,490) YORK (133,856) EAST YORK (97,679)	MARKHAM (105 341) VAUGHAN (56,766) RICHMOND HILL (44,358) NEWMARKET (33,186) GEORGINA (20,989) AURORA (19,438) KING TOWNSHIP (15,733) WHITCHURCH - STOUFFVILE (14,353) EAST GWILLIMBURY (13,991)	HAMILTON (307,690) STONEY CREEK (41,690) FLAMBOROUGH (25,541) DUNDAS (20,081) ANCASTER (16,542)	ST. CATHARINES (123,014) NIAGARA FALLS (71,088) WELLAND (45,173) FORT ERIE (24,073) PORT COLBORNE (18,653) GRIMSBY (16,719) THOROLD (16,086) LINCOLN (14,404) NIAGARA-ON-THE-LAKE (12,359) PELHAM (11,835)

The Highway 401 stations are located in a predominantly rural area. There are few large towns nearby, with Brockville being the largest to the east (50 kilometers away), and Kingston the largest to the west (25 kilometers away). Approximately half of the total population in the two surrounding counties resides in rural areas.

In contrast, both the Highway 400 stations and the Queen Elizabeth Way stations are located close to several large cities and towns. The surrounding counties have a much higher population density, with the vast majority of the population residing in urban and suburban areas.

Because of the proximity of the survey points on the Q.E.W. and Highway 400 to major metropolitan centres, it can be expected that a high level of local traffic would be captured by the surveys conducted at these points. The data for the Highway 401 corridor, in contrast, is unlikely to include many local movements. These differences in the type of traffic captured by the survey will be reflected in the outcome of the analysis in terms of traffic volumes, origin/destination patterns, and average trip distances.

iii. Origins and Destinations

Origin and destination data was extracted from the survey interviews for each of the corridors, and has been summarized in Tables II and III. Table II, Trip Distributions, below, gives a breakdown of traffic flows between regions of Canada and of the U.S.A. Table III, Top Five Origins and Destinations (p. 6), outlines the most common origins and destinations for traffic in each direction in the three corridors.

TABLE II: TRIP DISTRIBUTIONS

a) HIGHWAY 401 EASTERN CORRIDOR

BETWEEN		REGIONS EAST OF SURVEY POINT						TOTAL
		EASTERN PROVINCES		EASTERN U.S.A.		EASTERN ONTARIO		
REGIONS WEST OF SURVEY POINT	WESTERN CANADA	0.4%	(4,155 kms)	*	(2,555 kms)	*	(4,790 kms)	0.4%
	WESTERN U.S.A.	6.0%	(1,527 kms)	0.3%	(1,158 kms)	0.8%	(1,295 kms)	7.1%
	NORTHERN ONTARIO	0.2%	(1,125 kms)	*	(--)	*	(--)	0.2%
	SOUTHWEST ONTARIO	20.8%	(719 kms)	0.5%	(759 kms)	3.5%	(502 kms)	24.8%
	TORONTO AREA	35.1%	(655 kms)	1.9%	(817 kms)	7.2%	(398 kms)	44.2%
	CENTRAL ONTARIO	12.4%	(369 kms)	3.8%	(663 kms)	7.1%	(164 kms)	23.3%
	TOTAL	74.9%		6.5%		18.6%		100%

b) QUEEN ELIZABETH WAY CORRIDOR

BETWEEN		REGIONS SOUTH OF SURVEY POINT				TOTAL
		OUT OF PROVINCE		NIAGARA PENINSULA		
REGIONS NORTH OF SURVEY POINT	NORTHERN ONTARIO	0.5%	(722 kms)	1.3%	(579 kms)	1.8%
	EASTERN ONTARIO	1.7%	(703 kms)	2.4%	(233 kms)	4.1%
	GOLDEN HORSESHOE	31.2%	(495 kms)	36.7%	(98 kms)	67.9%
	SOUTHWEST ONTARIO	6.3%	(581 kms)	8.5%	(160 kms)	14.8%
	OTHER PROVINCES	0.9%	(1,469 kms)	1.9%	(1,918 kms)	2.8%
	U.S.A.	6.4%	(696 kms)	2.2%	(454 kms)	8.6%
	TOTAL	47.0%		53.0%		100%

c) HIGHWAY 400 CORRIDOR

BETWEEN		REGIONS SOUTH OF SURVEY POINT								TOTAL
		OUT OF PROVINCE		EASTERN ONTARIO		TORONTO AREA		SOUTHWEST ONTARIO		
REGIONS NORTH OF SURVEY POINT	NEWMARKET AREA	1.5%	(619 kms)	0.2%	(254 kms)	15.5%	(54 kms)	5.3%	(135 kms)	22.5%
	NEAR NORTH ONTARIO	4.2%	(878 kms)	1.4%	(259 kms)	28.6%	(120 kms)	8.6%	(195 kms)	42.8%
	NORTHEAST ONTARIO & QUEBEC	1.7%	(945 kms)	0.2%	(687 kms)	15.2%	(457 kms)	7.0%	(556 kms)	24.1%
	NORTHWEST ONTARIO	*	(2,132 kms)	*	(1,868 kms)	1.1%	(1444 kms)	0.5%	(1,529 kms)	1.6%
	WESTERN PROVINCES & STATES	0.4%	(4,336 kms)	0.1%	(3,188 kms)	6.6%	(3000 kms)	1.9%	(3,018 kms)	9.0%
	TOTAL	7.8%		1.9%		67.0%		23.4%		100%

PERCENT OF TOTAL TRUCK TRAFFIC (AVERAGE TRIP LENGTH)

* : LESS THAN 0.1%

-- : DATA NOT AVAILABLE

A significant proportion of truck movements on the Queen Elizabeth Way and Highway 401 involve end points which are outside of Ontario. The figures in Table II, p. 5, reveal that 74.9% of truck traffic surveyed for the **Highway 401** corridor was travelling to or from the eastern provinces, and another 6.5% was travelling to or from eastern U.S. states. 6.7% of truck traffic on this corridor neither originated nor was destined for points in Ontario. On the **Queen Elizabeth Way** corridor, 47% of movements had a southern endpoint outside of Ontario, and 11.4% had a northern endpoint outside of the province. 7.3% of the truck movements surveyed on this corridor neither originated nor were destined for a location in Ontario. The predominance of movements from/to points outside of the province on these corridors has implications for the successful implementation of load matching in Ontario.

As Table III indicates, Toronto figures prominently as an endpoint in all three corridors. An average of 42% of truck traffic on Highway 401 and 55% of truck traffic on Highway 400 either originated or was destined for Toronto. The average percentage of movements originating in or destined for Toronto on the Q.E.W. is a comparatively low 33%.

TABLE III: TOP FIVE ORIGINS AND DESTINATIONS

HIGHWAY 400 CORRIDOR

SOUTHBOUND TRAFFIC		NORTHBOUND TRAFFIC	
ORIGINS		DESTINATIONS	
1. BARRIE	16.2%	1. BARRIE	19.7%
2. NEWMARKET	7.0%	2. SUDBURY	7.6%
3. SUDBURY	6.0%	3. NEWMARKET	5.9%
4. BRADFORD	5.0%	4. BRADFORD	5.4%
5. AURORA	4.6%	5. NORTH BAY	5.0%
OTHERS	61.1%	OTHERS	56.4%
DESTINATIONS		ORIGINS	
1. TORONTO	54.5%	1. TORONTO	56.7%
2. MISSISSAUGA	7.9%	2. MISSISSAUGA	5.3%
3. HAMILTON	3.1%	3. HAMILTON	3.3%
4. BRAMPTON	2.6%	4. BRAMPTON	2.8%
5. KITCHENER	2.3%	5. KITCHENER	2.6%
OTHERS	29.5%	OTHERS	29.2%

QUEEN ELIZABETH WAY CORRIDOR

NORTHBOUND TRAFFIC		SOUTHBOUND TRAFFIC	
ORIGINS		DESTINATIONS	
1. NEW YORK	22.8%	1. NEW YORK	27.2%
2. ST. CATHARINES	16.8%	2. ST. CATHARINES	15.3%
3. NIAGARA FALLS	10.3%	3. NIAGARA FALLS	12.2%
4. PENNSYLVANIA	5.7%	4. WELLAND	5.5%
5. WELLAND	5.1%	5. OHIO	5.2%
OTHERS	39.4%	OTHERS	34.7%
DESTINATIONS		ORIGINS	
1. TORONTO	36.3%	1. TORONTO	30.0%
2. HAMILTON	10.1%	2. HAMILTON	9.7%
3. MISSISSAUGA	7.3%	3. MICHIGAN	7.7%
4. MICHIGAN	6.2%	4. MISSISSAUGA	7.6%
5. BRAMPTON	3.3%	5. BURLINGTON	3.9%
OTHERS	36.8%	OTHERS	41.2%

HIGHWAY 401 CORRIDOR

WESTBOUND TRAFFIC		EASTBOUND TRAFFIC	
ORIGINS		DESTINATIONS	
1. QUEBEC	67.1%	1. QUEBEC	69.2%
2. OTTAWA	6.1%	2. OTTAWA	5.4%
3. BROCKVILLE	4.9%	3. BROCKVILLE	4.5%
4. CORNWALL	4.5%	4. NEW BRUNSWICK	3.4%
5. NEW YORK	4.2%	5. NOVA SCOTIA	3.1%
OTHERS	13.2%	OTHERS	14.4%
DESTINATIONS		ORIGINS	
1. TORONTO	41.1%	1. TORONTO	43.5%
2. KINGSTON	12.9%	2. KINGSTON	10.8%
3. BELLEVILLE	2.8%	3. HAMILTON	4.6%
4. HAMILTON	2.4%	4. BELLEVILLE	2.5%
5. BRAMPTON	2.3%	5. MISSISSAUGA	1.9%
5. LONDON	2.3%	OTHERS	36.7%
OTHERS	36.3%		

In terms of endpoints opposite to Toronto, at least half of the movements on the Highway 401 corridor and on the Queen Elizabeth Way had a second endpoint which fell amongst the top five origins and destinations. On average, 14% of traffic on Highway 401 and 37% of traffic on the Q.E.W. did not have their second endpoint in the top five origins and destinations. On Highway 400 however, over 55% of truck traffic interviewed gave a second endpoint which did not make the top five category.

The low occurrence of trips originating or destined for Toronto on the Q.E.W. corridor, and the diversity of endpoints north of the survey point on Highway 400 will likely have a negative impact on the potential to match loads on these corridors.

iv. Traffic Volumes

In addition to the survey interviews, an hourly vehicle count was conducted for each of the corridors, broken down by vehicle type. Diagram I on p. 8 illustrates the pattern of total traffic flow in each of the three corridors over a twenty-four hour period, based on the data obtained from these counts.

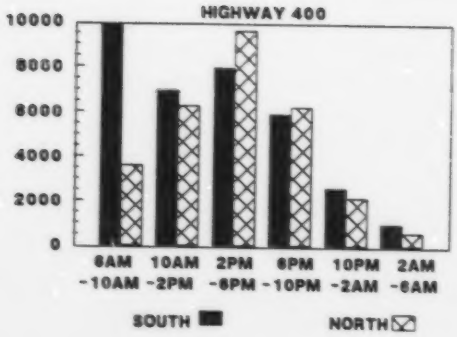
The graphs illustrate that the Queen Elizabeth Way and Highway 400 survey points experienced high traffic levels throughout the day, with peaks and troughs reflecting morning and evening rush hours. On average, more than 28,000 vehicles passed these two survey points in each direction in a twenty-four hour period. Traffic volumes at the Highway 401 survey point were comparatively low throughout the day in both directions, averaging approximately 9,500 vehicles in each direction in a twenty-four hour period.

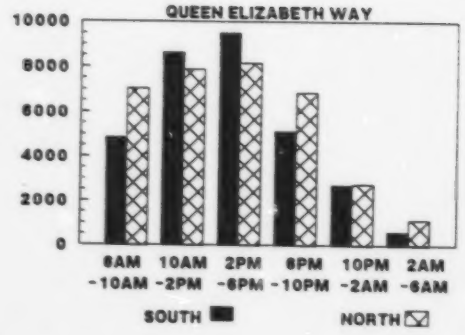
Diagram II on p. 8 illustrates the pattern of traffic volumes for trucks only in each of the three corridors. The truck traffic patterns for the Queen Elizabeth Way and the Highway 400 corridors are similar to the total traffic pattern as illustrated in Diagram I. This means that trucks in these two corridors are competing for road space during the time of day when total traffic levels are highest.

In contrast to the other two corridors, truck traffic levels on the Highway 401 corridor peaked during the evening, when total traffic levels were low. This indicates that, at the survey point for Highway 401, truck traffic is not competing head to head with car traffic during high use hours.

While total traffic levels were much lower on the Highway 401 corridor than on the other two corridors, truck traffic levels were only slightly lower. An average of 2,850 trucks passed the Highway 401 survey point in a twenty-four hour period, accounting for 30.1% of the total traffic volume. This compares to 4,000 trucks on the Q.E.W. (12.4% of the total traffic volume), and 3,000 trucks on Highway 400 (9.4% of the total traffic volume).

DIAGRAM I: TOTAL TRAFFIC VOLUMES





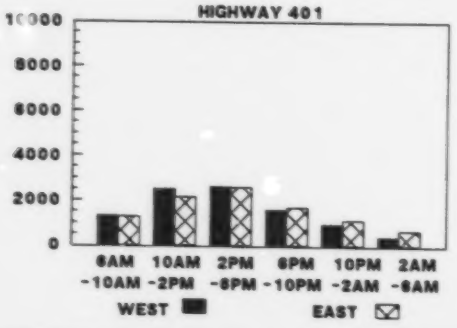
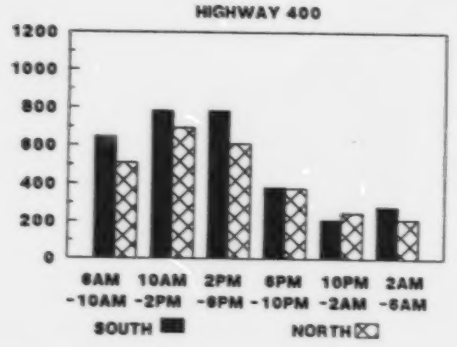
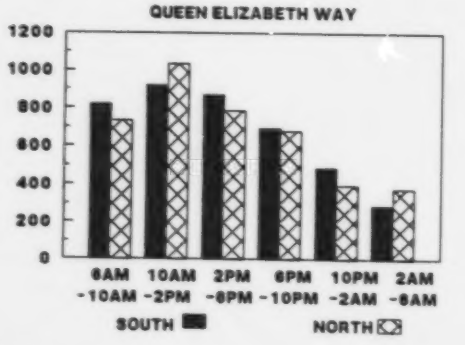
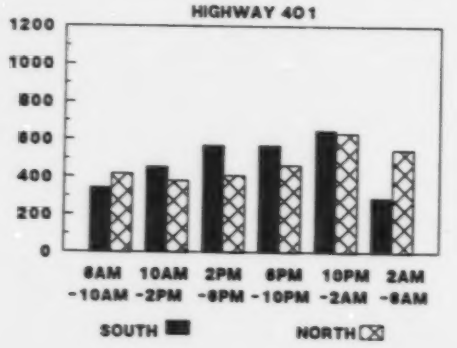


DIAGRAM II: TRUCK TRAFFIC VOLUMES







v. Empty Movements Versus Total Movements

In order to benefit from potential load matching, trucks must be able to transport heterogeneous freight. Specialized vehicles such as cement mixers, tankers, automobile carriers, and other trucks designed for a specific use are unable to backhaul other types of freight, and were therefore excluded from the survey interviews. Thus, interview data was obtained for straight trucks with or without trailers and tractors with at least one trailer. Annual figures used in Tables IV through XIII have been projected from interview survey data and apply only to these types of vehicles, and may vary slightly from the results of the vehicle count.

Table IV contains the projected number of one-way truck moves and one-way empty truck moves passing each of the three survey points annually. The Queen Elizabeth Way corridor experiences a higher level of truck traffic of than either Highway 400 or Highway 401. Volumes on the latter two corridors are similar.

TABLE IV: NUMBER OF ONE-WAY MOVES ANNUALLY
(000)

CORRIDOR	EMPTY	TOTAL	PERCENT EMPTY
HIGHWAY 401	175	1,212	14.5%
HIGHWAY 400	330	1,170	28.2%
Q.E.W.	415	1,623	25.6%

It was observed in the previous study that the percentage of trucks which are empty decreases in proportion to the length of haul. It can therefore be expected that corridors with a high level of local traffic will experience a higher percentage of empty movements. This expectation is borne out by the projected annual figures for empty and total truck movements. At the Highway 400 and QEW survey points, which are located close to metropolitan centres, over one-quarter of all truck movements involve empty vehicles, while less than fifteen percent of vehicles passing the Highway 401 survey point are empty.

Using the origin and destination data obtained in the survey, one-way downtown to downtown distances were determined, based on the most likely route passing the inspection station at which the interview took place. Where other provinces or states were given as an end point, the major centre in that jurisdiction closest to Ontario's border was used. The projected total number of annual kilometers driven by all trucks and by empty trucks is outlined in Table V.

TABLE V: ONE-WAY KILOMETERS DRIVEN ANNUALLY
(000,000)

CORRIDOR	EMPTY KM'S DRIVEN	TOTAL KM'S DRIVEN	PERCENT EMPTY
HIGHWAY 401	89	792	11.2%
HIGHWAY 400	84	635	13.3%
Q.E.W.	109	606	18.0%

The higher occurrence of local traffic on the Q.E.W. and Highway 400 is reflected in the total number of kilometers driven by the trucks passing these stations annually. The truck traffic for these two corridors involve a much lower total number of kilometers in comparison to Highway 401.

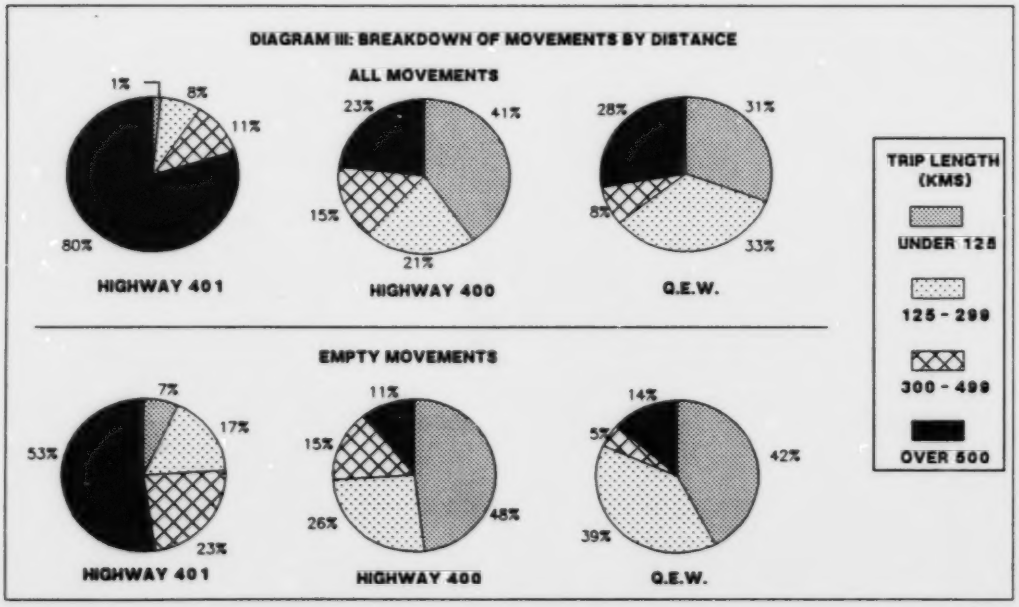
The percentage of kilometers driven empty is lower than percentage of movements which are empty for each corridor. For example, while 28.2% of trucks passing the Queen Elizabeth Way survey point are empty, these vehicles account for only 18.0% of kilometers driven by trucks in this corridor.

The average distances travelled by empty movements and by all movements surveyed in each corridor are outlined in Table VI. The highest average length of haul for empty moves and for total moves occurs in Highway 401, reflecting the few number of local moves and the high number of very long distance moves. The Queen Elizabeth Way, on the other hand, has a relatively low average distance for both total moves and for empty moves, again reflecting the high incidence of local movements. There is a significant difference between the average distance for empty moves and the average distance for all moves passing the Highway 400 stations. This suggests that, in this corridor, empty movements tend to be local, while loaded moves are long distance.

TABLE VI: AVERAGE TRIP LENGTH
(KILOMETERS)

CORRIDOR	EMPTY MOVEMENTS	TOTAL MOVEMENTS
HIGHWAY 401	507	653
HIGHWAY 400	255	543
Q.E.W.	262	373

Diagram III below illustrates the breakdown of total movements and empty movements by distance.

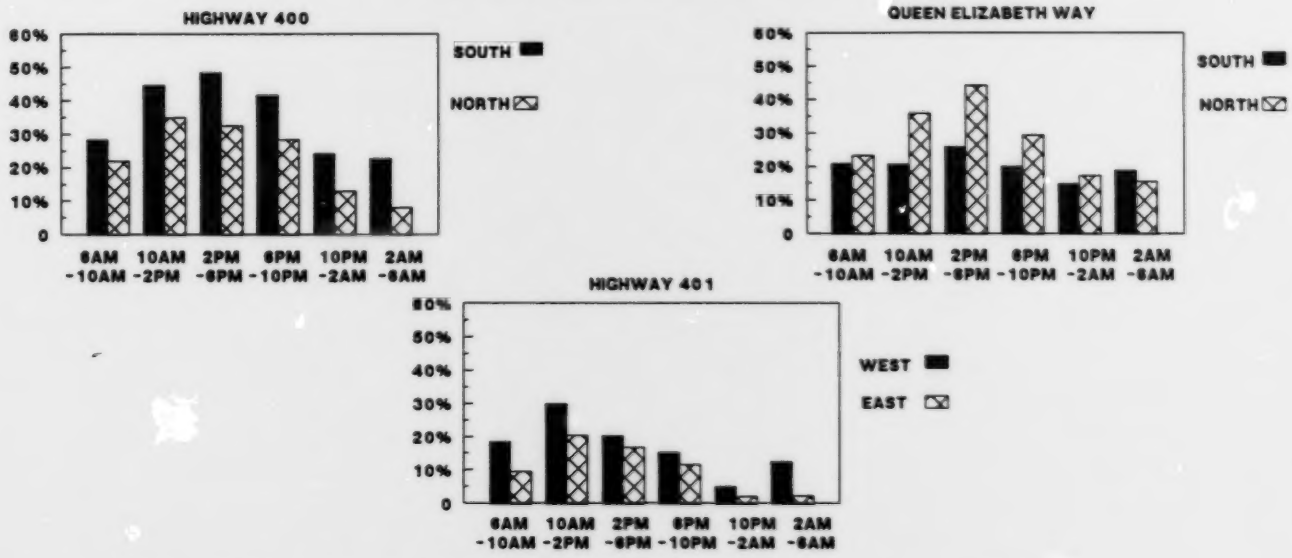


Over 75% of truck movements on the Highway 401 corridor involve one-way trip lengths of 500 kilometers or more. Very few trips surveyed on this corridor involved distances of less than 125 kilometers. This contrasts significantly with the results for the Queen Elizabeth Way and the Highway 400 corridors, where less than one-third of the trips surveyed were over 500 kilometers.

In all three corridors, shorter distance trips account for a higher proportion of empty moves than of total moves. Very long distance trips (over 500 kilometers), on the other hand, make up a proportionately smaller share of empty moves than of total moves in all three corridors. This again confirms the observation that the occurrence of empty moves is inversely related to the length of haul.

Diagram IV below illustrates the percentage of total trucks surveyed which were empty. These charts indicate that, in all three corridors, a high proportion of trucks operating during the day are empty. This means that a reduction in the number of empty truck movements through load matching would likely result in a reduction in total traffic volumes during peak use hours. This would particularly benefit the Highway 400 and Queen Elizabeth Way corridors, where a significant proportion of trucks are empty, and where truck traffic competes head to head with car traffic during daylight hours, as illustrated in Diagrams I and II.

DIAGRAM IV: PERCENT OF TOTAL TRUCKS WHICH ARE EMPTY



C. POTENTIAL REDUCTION IN TRUCK TRAFFIC VOLUMES THROUGH THE ELIMINATION OF EMPTY MOVEMENTS

In the initial analysis of movements between Northern and Southern Ontario, it was assumed that the potential existed to eliminate one round trip where an empty movement occurred in both directions between the same locations. Using this rationale, empty movements were matched for each of the three corridors.

i. Methodology

The data for empty movements at each inspection station were sorted by origin-destination, service type (for-hire/private) and vehicle type. For each corridor, matches were made between similar empty movements in opposite directions, with each movement being used only once. Each matched pair is equivalent to one round trip which could potentially be eliminated.

1. Matches Possible with Licensing Restrictions

a. Empty movements by <u>for-hire</u> operators matched with <u>for-hire</u> movements involving the same end points and vehicle type. (Example I, Diagram V).

b. Empty movements by <u>for-hire</u> operators matched with empty movements by <u>private</u> operators with same vehicle type and origin-destination combination.

2. Additional Matches Possible without Licensing Restrictions

After all matches possible under 1987 licensing restrictions had been made, additional matches were made assuming that such restrictions were not in place. This was performed in the following order:

a. Empty movements by <u>private</u> operators of same origin - destination combination and vehicle type.

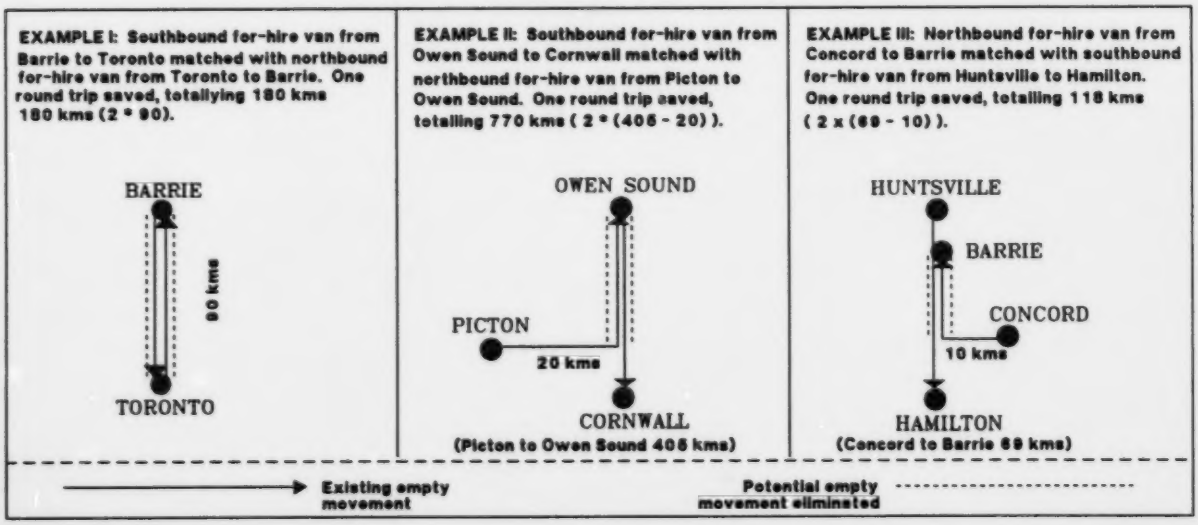
b. Empty movements by <u>for-hire</u> operators of same vehicle type, and one end point in common, provided that other end points are within 40 kilometers of each other, or that one end point is on the route for the other movement (Example II, Diagram V).

c. Empty movements for <u>private</u> operators of same vehicle type and at least one common end point, as described in **b.** above.

d. Empty movements by <u>for-hire</u> operators of same vehicle type but different origin-destination combination, where both end-points of one movement fall within the route of second movement (Example III, Diagram V).

e. Empty movements by <u>private</u> operators matched with empty movements of <u>for-hire</u> operators with same vehicle type and one end point in common.

DIAGRAM V: EXAMPLES OF LOAD MATCHING


EXAMPLE I: Southbound for-hire van from Barrie to Toronto matched with northbound for-hire van from Toronto to Barrie. One round trip saved, totallying 180 kms 180 kms (2 * 90).
BARRIE
90 kms
TORONTO
EXAMPLE II: Southbound for-hire van from Owen Sound to Cornwall matched with northbound for-hire van from Picton to Owen Sound. One round trip saved, totalling 770 kms (2 * (406 - 20)).
OWEN SOUND
PICTON
20 kms
CORNWALL
(Picton to Owen Sound 406 kms)
EXAMPLE III: Northbound for-hire van from Concord to Barrie matched with southbound for-hire van from Huntsville to Hamilton. One round trip saved, totalling 118 kms (2 x (69 - 10)).
HUNTSVILLE
BARRIE
CONCORD
10 kms
HAMILTON
(Concord to Barrie 69 kms)
Existing empty movement
Potential empty movement eliminated

ii. Potential Reduction of Round Trips

The projected potential number of round trips which could be eliminated annually through load matching is outlined in Table VII. As these figures indicate, all three corridors have substantial potential for the reduction of empty movements. The majority of these reductions are possible only through alterations to regulations in place in 1987.

TABLE VII: POTENTIAL NUMBER OF ROUND TRIPS ELIMINATED ANNUALLY
(000)

CORRIDOR	WITH RESTRICTIONS	ADDITIONAL, WITHOUT RESTRICTIONS	TOTAL
HIGHWAY 401	11.8	45.7	57.5
HIGHWAY 400	33.2	74.1	107.3
Q.E.W.	44.3	68.3	112.6

In terms of absolute numbers, the potential for reduction of empty movements is smallest on the Highway 401 corridor. This is largely due to the relatively low occurrence of empty vehicles on this route. However, as Table VIII indicates, all three corridors have the potential to reduce empty movements by at least 50% annually, representing at least a 9.5% reduction in the total number of movements in each corridor.

TABLE VIII: PERCENT OF TRIPS ELIMINATED

CORRIDOR	PERCENT OF TOTAL TRIPS	PERCENT OF EMPTY TRIPS
HIGHWAY 401	9.5%	65.6%
HIGHWAY 400	18.3%	64.9%
Q.E.W.	13.9%	54.3%

iii. Potential Reduction of Empty Kilometers

The sum of round trip kilometers saved through matching loads yields the potential number of empty kilometers which could be eliminated for trips surveyed. Table IX outlines the projected number of empty kilometers which could be eliminated annually on each corridor.

TABLE IX: POTENTIAL NUMBER OF ROUND TRIP KM'S ELIMINATED ANNUALLY
(000,000)

CORRIDOR	WITH RESTRICTIONS	ADDITIONAL, WITHOUT RESTRICTIONS	TOTAL
HIGHWAY 401	12.8	39.7	52.5
HIGHWAY 400	7.0	31.3	38.3
Q.E.W.	15.8	28.0	43.8

Despite the low number of trips which could be eliminated on Highway 401, this corridor has the greatest potential for reduction of empty kilometers due to the long average trip length for empty vehicles. However, all three corridors have the potential to reduce the number of kilometers driven by empty trucks by at least 38.3 million annually.

As Table X indicates, the number of kilometers which could be eliminated account for a high of 59.2% of empty kilometers on Highway 401, and a low of 40.3% on the Q.E.W. The low potential reduction in empty kilometers for the Queen Elizabeth Way can be attributed to the varying locations of origin/destination points north of the survey point, as illustrated in Table III, p. 6, as well as the short average trip length for empty movements in this corridor, as illustrated in Table VI, p. 10.

TABLE X: PERCENT OF KILOMETERS ELIMINATED

CORRIDOR	PERCENT OF TOTAL KM'S DRIVEN	PERCENT OF KM'S DRIVEN EMPTY
HIGHWAY 401	6.6%	59.2%
HIGHWAY 400	6.0%	45.5%
Q.E.W.	7.2%	40.3%

For all three corridors, total truck traffic could be reduced by at least 6% percent through the reduction of empty movements, with a high of 7.2% reduction in total truck traffic in the Queen Elizabeth Way corridor, which experienced the greatest percentage of kilometers driven empty.

iv. Cost Analysis

Transportation costs were calculated using the Ministry of Transportation Truck Costing Model (see Appendix B for description of costing methodology). Potential savings were derived from the cost of empty kilometers driven which could be eliminated through matching loads, less additional pick up and delivery costs to transport the second load, based on a deadhead distance of 40 kilometers.

Table XI outlines the cost of empty movements versus the cost of all movements annually. In all three corridors, at least ten percent of the cost for all movements surveyed is incurred by empty movements. The ranking in this category reflects the number of kilometers driven by all trucks and by empty trucks, as summarized in Table V, p. 9. The Queen Elizabeth Way had the highest absolute cost of empty movements, and the lowest cost of all movements on this corridor.

TABLE XI: COST OF EMPTY MOVEMENTS VERSUS COST OF ALL MOVEMENTS ANNUALLY
($000,000)

CORRIDOR	COST OF EMPTY MOVEMENTS	COST OF ALL MOVEMENTS	% OF TOTAL COST INCURRED ON EMPTY MOVEMENTS
HIGHWAY 401	71.4	652.8	10.9%
HIGHWAY 400	66.3	517.8	12.8%
Q.E.W.	86.2	491.1	17.5%

The potential annual money savings resulting from the reduction of empty movements through load matching is outlined in Table XII. The reduction in empty movements through load matching could potentially result in a savings of more than $26,000,000 annually in each of the three corridors, with a high of $40,900,000 for Highway 401.

TABLE XII: POTENTIAL SAVINGS
($000,000)

CORRIDOR	WITH RESTRICTIONS	ADDITIONAL, WITHOUT RESTRICTIONS	TOTAL
HIGHWAY 401	10.1	30.8	40.9
HIGHWAY 400	5.2	21.5	26.7
Q.E.W.	11.2	20.4	31.6

As Table XIII indicates, the potential money savings resulting from load matching represents at least a 36.7% reduction of costs incurred for empty movements. Highway 401, which had a very high average length of haul for empty movements, could potentially reduce the costs for empty movements by 57.2%. In all three corridors, the savings amount to a reduction of more than 5% of costs incurred for all movements.

TABLE XIII: PERCENTAGE OF COSTS SAVED

CORRIDOR	PERCENT OF TOTAL COSTS	PERCENT OF COSTS OF EMPTY MOVEMENTS
HIGHWAY 401	6.3%	57.2%
HIGHWAY 400	5.2%	40.4%
Q.E.W.	6.4%	36.7%

D. CONCLUSIONS

The initial analysis of movements between Northern Ontario and Southern Ontario involved data gathered for intraprovincial movements on Highway 400. The earlier study concluded that, with better matching of loads, significant savings in transportation costs and trucking kilometers driven were achievable. These savings were deemed possible only with "substantial change to market entry constraints", and with "the establishment of an information system which would enable the effective matching of loads".

The present study was undertaken to determine the applicability of these conclusions to other parts of Ontario. The analysis of survey data obtained for intraprovincial and extraprovincial movements on Highway 400, Highway 401 and the Queen Elizabeth Way has demonstrated that the earlier conclusions are true for traffic corridors leading north, east and south from Toronto. There are, however, significant variations in traffic patterns and movement characteristics on these three corridors.

The Queen Elizabeth Way experienced the highest volume of truck traffic of the three corridors, approximately one-quarter of which was found to involve empty vehicles. The movements on this corridor were generally short in nature, both for loaded and for empty trucks. Truck volumes on this corridor were particularly high during traditional "rush hour" periods, at which time up to 40% of trucks were empty. Approximately one-half of truck traffic on the Q.E.W. had an origin or destination outside of Ontario. 7.3% of trucks travelling in this corridor were using Ontario's roads as a bridge only, and neither originated nor were destined for points in Ontario.

Highway 400 experienced much lower truck traffic volumes compared to the Q.E.W., but had a similar proportion of empty vehicles. The empty movements on this corridor were generally short in nature, while loaded movements involved much longer distances. As with the Q.E.W., truck volumes on this corridor peaked during "rush hour" periods, during which times the percent of trucks which were empty ranged from 33% to more than 50%. Very few movements on this corridor were extraprovincial in nature.

Truck traffic volumes on Highway 401 were comparable to Highway 400, but accounted for a higher proportion of total traffic. The movements on this corridor were generally very long in nature, with more than 75% involving distances greater than 500 kilometers one-way. Truck traffic was relatively low during "rush hour" periods, peaking in late evening. As with the Q.E.W., a very high proportion of movements on this corridor involved endpoints outside of the province. At least 6.7% of truck movements on this corridor both originated and were destined for points outside of Ontario. This percentage could be higher, since data could only be obtained for eastbound movements between the U.S. and points east of Gananoque, due to the location of the westbound station.

In all three corridors, there is a significant potential to reduce empty movements through improved load matching. Over 50% of empty trips could be eliminated annually in each of the three corridors, reducing the number of kilometers driven empty by at least 40%. This would amount to at 9.5% to 18.3% reduction in truck traffic volumes at the survey points, and a 6.0% to 7.2% reduction in total kilometers driven annually. These reductions would result in reduced truck traffic levels during "rush hour" periods, when the percentage of trucks which are empty is highest.

The costs incurred for empty movements would similarly be reduced by 36.7% to 57.2%, amounting to a 5.2% to 6.4% reduction in the costs of truck movements on these corridors. This translates into a savings of at least $26,700,000 in each of the three corridors annually. As was found in the earlier study, the majority of these potential savings are possible only through changes to market entry constraints. Less than one-quarter of the savings would be possible under market restrictions in place at the time of the survey.

Because of the high level of extraprovincial truck traffic on the Q.E.W. and Highway 401, a load matching information system would have to be interprovincial and/or international in scope in order to fully realize potential savings in these corridors.

The location of the survey points had a considerable influence on the nature of the data which was obtained. The level of local traffic affected the values derived for traffic volumes, origin/destination patterns, and average trip distances, and percentage of vehicles which were empty, so that these values may not be applicable throughout the corridor. However, the savings derived in this analysis can be regarded as a minimum level possible under ideal load matching conditions in these corridors. Alternate survey points would find additional, short-distance empty movements which could potentially be eliminated.

E. RECOMMENDATIONS FOR FURTHER RESEARCH

Surveys have been conducted during the Winter, Spring, Summer and Autumn of 1988 on the four major corridors leading from Toronto. An analysis of the results from these surveys should identify any seasonal variations in load factors and traffic levels, and thus provide a more complete indication of the potential to reduce empty movements in Southern Ontario.

Additional surveys should be conducted in 1991 to identify the impact of regulatory reforms at the federal and provincial levels on the volume of truck traffic and load patterns in Southern Ontario.

APPENDIX A: SURVEY METHODOLOGY

i. DATA COLLECTION

During the summer of 1987, the Ministry of Transportation, Ontario conducted truck surveys at the following locations.

CORRIDOR	FROM	TO
Q.E.W. SOUTHBOUND	AUG. 5th, 12 AM	AUG. 6th, 6 AM
Q.E.W. NORTHBOUND	AUG. 6th, 6 AM	AUG. 7th, 2 PM
401 WESTBOUND	AUG. 11th, 6 AM	AUG. 12th, 2 PM
401 EASTBOUND	AUG. 12th, 2 PM	AUG. 13th, 10 PM
400 SOUTHBOUND	AUG. 17th, 10 AM	AUG. 19th, 10 AM
400 NORTHBOUND	AUG. 19th, 10 AM	AUG. 21th, 10 AM

Data was collected on general traffic flows through a classification study, which determined the total number of vehicles passing the inspection stations during the survey period. A total vehicle count per hour was obtained for cars as well as for truck types such as straight trucks, tractor trailers and specialized equipment.

In addition, a questionnaire was administered by trained summer students to a random sample of tractor trailer and straight truck drivers. Data obtained through the questionnaire concerned employment type, origin, destination, weight of freight, number of shipments, commodity type and cube utilized. Observations were recorded on equipment configuration, trailer style, the number of axles and the time of interview. The gross vehicle weight was recorded from the weighing platform.

Driver co-operation in the questionnaire was excellent, with a participation rate of more than 99% of the selected drivers. The following table outlines the interview rate at each of the inspection stations.

CORRIDOR	ELIGIBLE TRUCKS PASSING STATIONS	DRIVERS INTERVIEWED	PERCENT INTERVIEWED
Q.E.W. SOUTHBOUND	3,920	1,185	30.2%
Q.E.W. NORTHBOUND	4,509	1,379	30.6%
401 WESTBOUND	3,212	1,018	31.7%
401 EASTBOUND	3,262	1,241	38.0%
400 SOUTHBOUND	4,669	1,372	29.4%
400 NORTHBOUND	4,259	1,486	34.9%

ii. DATA COMPILATION

Once the interviews were completed, each origin and destination was coded into Provincial Transportation Zones in order to facilitate transportation corridor analysis. The information from the questionnaires was entered into a micro computer data base program.

A 10% random sample of questionnaires was then verified to ensure keypunch accuracy. In addition, a series of edit checks were performed to verify the accuracy of the data contained in the questionnaire. These checks included:

- Verification that the recorded shipment weight was correct by comparing the recorded shipment weight plus the estimated vehicle weight (1) to the total weight obtained from the scale reading.

- A comparison of the number of axles to the vehicle configuration.

- A comparison of shipment weight, number of shipments, cube and freight type. All four factors had to be recorded as zero for a trip to be considered as an empty move.

- Verification that southbound loads had southern destinations and northbound loads had northern destinations.

Corrections were made to questionnaires when obvious errors were discovered. If an error could not be corrected, the questionnaire was discarded. Approximately 3% of the questionnaires fell into this category.

APPENDIX B: COSTING METHODOLOGY

In the Ontario Ministry of Transportation costing model, costs are calculated separately for straight truck moves and for tractor trailer moves because the cost per kilometer is significantly different for these two types of equipment.

The equipment cost per kilometer shown for **straight trucks** is based on a new truck with a van box mounted on a 7.3 m chassis, powered by a diesel engine and equipped with a 5 speed transmission and power steering. The equipment cost per kilometer shown for a **tractor trailer** unit is based on the costs for a new tractor powered with the equivalent of a 315 diesel Cummins engine and equipped with a 9 speed transmission and 40,000 lb. rear axle. The trailer costs are based on a new 48' 102" tandem axle van trailer.

1987 ONTARIO TRUCK OPERATING COST PER KILOMETRE

	STRAIGHT TRUCK	TRACTOR TRAILER
EQUIPMENT		
Variable	$.211	$.200
Fixed	$.124	$.298
LABOUR		
Wage	$.175	$.185
Benefits	$.058	$.061
TOTAL COSTS	$.568	$.834

It was felt that the costs for these equipment types would provide the best average for the wide range of straight trucks and tractor trailer combinations that can be found. For example, although the costs for a tractor flatbed combination would be lower than those shown above the costs of a tractor train combination would be higher.

Trimac Consulting Services developed 1987 unit costs based on their "Operating Costs of Trucks in Canada - 1986", which were incorporated into the Ontario Ministry of Transportation's Truck Costing Model. 1987 Costs are used in this analysis since the survey was conducted in 1987.

Equipment variable costs include costs for maintenance, tires and fuel. Fuel costs are based on fuel consumption and the price of diesel fuel. **Equipment fixed costs** include depreciation, interest, licence, insurance, cleaning and misc. cost. Annual projected fixed costs are converted into cost/kilometer by assuming 70,000 kilometer/year for straight trucks, 140,000 kilometers/year for tractors, and 50,000 kilometers/year for trailers.

Labour wages were developed assuming an average hourly rate of $12.25 per hour and an average speed of 70 kilometer/hour. The resulting labour rate provides a conservative estimate of costs because it is lower than the distance rate paid by medium and large sized carriers. **Labour benefits** include an allowance for overtime, fringe benefits, vacation pay and statutory holidays, and amounts to 33% of the base wage.

APPENDIX C: DATA RELIABILITY

i. ANNUAL PROJECTIONS

Annual figures were projected as follows:

ANNUAL NUMBER	= 250 x DAILY FACTOR
DAILY NUMBER	= DAILY FACTOR * INTERVIEW FACTOR x NUMBER OF INTERVIEWS
DAILY FACTOR	= Adjustment to 24 hour period, where survey was conducted for more than 24 hours
INTERVIEW FACTOR	= Percent of eligible drivers interviewed, based on vehicle count conducted during each survey period

It should be noted that this method employed to estimate annual data does not provide precise projections as it does not take into account daily or seasonal variations. However, it does provide an order of magnitude, and probably understates trucking activity since. By basing the calculation on 250 days, trucking activity on holidays or weekends are not taken into consideration.

ii. ORIGIN/DESTINATION ASSUMPTIONS

In this analysis, where an origin/destination outside of Ontario was given as the trip's endpoint(s), the major centre in that jurisdiction closest to the Inspection Station in question was used to derive distance measurements. While some distortions in traffic flow have likely resulted from this assumption, it has provided a conservative estimate of distance travelled and hence a conservative estimate of savings possible. For example, trips passing the Gananoque station destined for New York State were assumed to have a Syracuse destination. If the trip was actually destined for Buffalo, New York, it would have had a higher percentage of distance on Ontario roads than projected.

The methodology in this paper differs from the initial analysis of movements between Northern and Southern Ontario which excluded extraprovincial movements in the calculation of potential savings. Also different in this analysis was the calculation of distances between the initial origin and final destination rather than using Toronto as one of the end points as was done in the earlier study. As a consequence, distances travelled and potential savings are higher in this study than in the previous one.

iii. LOAD MATCHING ASSUMPTIONS

There are several factors which will reduce the amount of potential savings that could be achieved. Some loads will move regardless of empty move costs because of service considerations. In some situations, a load will have to move immediately before a backhaul load is found. Timing and scheduling may prevent the matching of other loads. For example, drivers may not have sufficient time to complete an additional pick up or delivery and keep within allowed hours of work.

On the other hand, this analysis does not take into consideration the possibility of matching partially loaded trailers. As shown below, a significant proportion of the equipment moves involved partially loaded vehicles.

CORRIDOR	PERCENT OF NON-EMPTY TRUCKS WHICH WERE LESS THAN 50% LOADED
Q.E.W. SOUTHBOUND	22.6%
Q.E.W. NORTHBOUND	18.7%
401 WESTBOUND	12.6%
401 EASTBOUND	13.1%
400 SOUTHBOUND	13.9%
400 NORTHBOUND	17.6%

Thus, although the potential savings shown in this report represent an optimum elimination of empty movements, it would appear that the potential savings projected are quite realistic, and could theoretically be exceeded if space on partially loaded trailers was utilized.